CNG Fuel Systems Technology

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Overview

- Enhanced Damage Detection and Inspection Technologies for CNG Fuel Tanks
- Reference Guide for Integration of Natural Gas Vehicle Fuel Systems

Enhanced Damage Detection and Inspection Technologies for CNG Fuel Tanks

- Improve Safety and Reliability Through Routine Monitoring of Threats, Damage And/or Damage Growth
- Identify Faulty or Damaged Cylinder So That Action Can Be Taken Before Safety Is Threatened
- Improve End User Acceptance and Confidence

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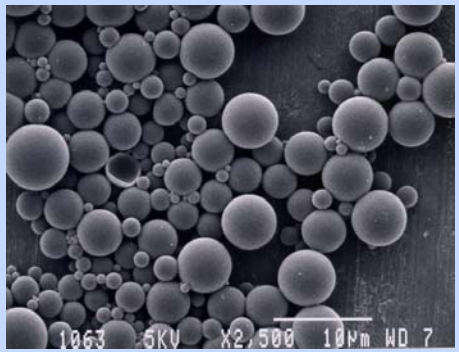
Inspection Methods In Development

- Damage Indicator Coating (Visual Inspection)
  - Spray-on Cylinder Coating Which Changes Color on Impact to Indicate That a Cylinder May Have Been Damaged
- Instrumented Hammer (Periodic Inspection / Assessment)
  - Specialty Device Which Measures Dynamic Response of Potentially Damaged Area to Light Impact (an Electronic Coin Tap Test)
- Real Time Monitoring (Passive On-Board System)
  - Continuously Monitor Cylinders for Acoustic Signals and Vibrations From Impacts Which May Be Sufficient to Cause Damage. Uses Inexpensive PVDF Transducers
- Acousto-Ultrasonics (Active On-Board System)
  - Active Acoustic "Pitch-catch" On-board Inspection Method to Search for Damage by Monitoring Decay in Acoustic Signals.

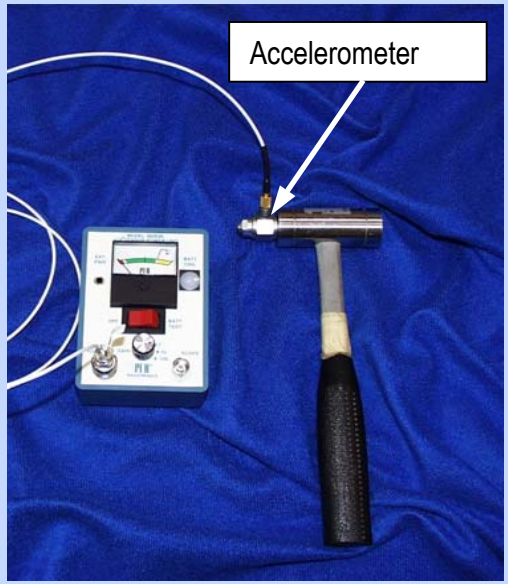
Damage Indicator Coating

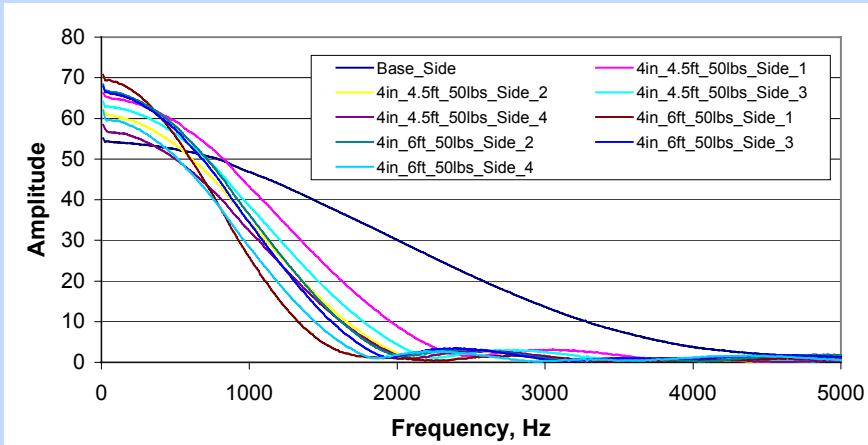
- Concept:
  - Enhance routine and detailed visual inspections by use of coating which changes color on impact to indicate that a cylinder *may* have been damaged
- Potential Advantages:
  - Simple concept
  - Enhances and reinforces existing visual inspection methods
- Limitations
  - Will require secondary assessment method to confirm damage
- Status
  - Starting Initial Field Tests



Instrumented Hammer

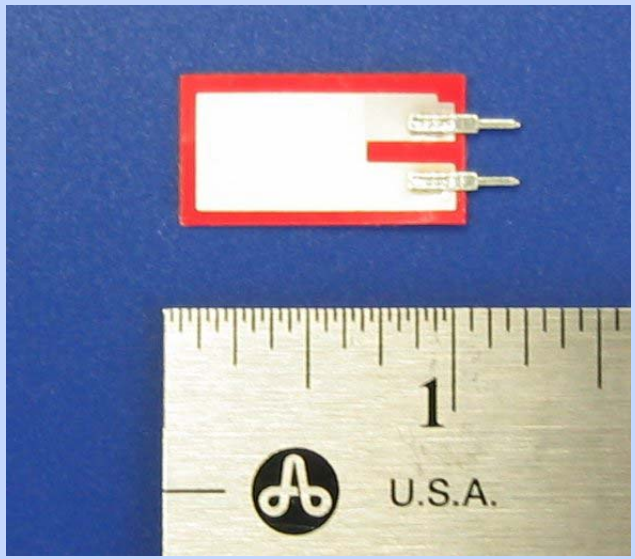
- Concept
  - Hammer With Accelerometer Which Measures Dynamic (Acoustic) Response of Potentially Damaged Area to Light Impact
  - Fundamentally Serves As an Electronic Coin Tap Test
- Advantages
  - Evidence Shows It Can Readily Identify Delamination and Discriminate Between Local Crushing Damage and Global Delamination
- Limitations
  - Must Tap Entire Surface Area to Locate Damage or Be Used With Damage Indicator Coating
- Status
  - Commercial Potential

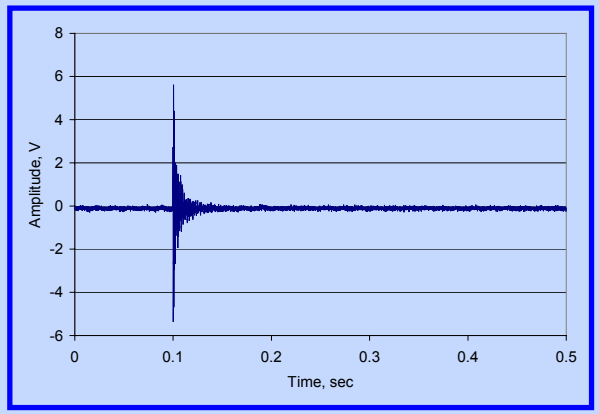




Real-time Monitoring of Significant Impacts

- Concept
  - Monitor Cylinder Continuously for Acoustic Signals Which Indicate Impact Which May Be Sufficient to Cause Damage
- Potential Advantages
  - Simple Concept and Simple Implementation
  - Inexpensive Sensors and Instrumentation
  - Detects Impact and Potential for Damage As Soon As It Occurs
- Limitations
  - May Be Active Only When Cylinder Is on Vehicle and System Is on
  - Not Sensitive to Gradual Degradation
- Status
  - Commercial Potential





Acousto-Ultrasonic (AUT) Inspection

- **Concept**
  - Demonstrated On-board Inspection Technology Which Appears Capable of Reliably Locating Damage
  - Uses Inexpensive Embedded Transducers for Listening
  - Significant "Early Detection" Advantages Over Indirect Acoustic Emission Methods
- **Potential Advantages**
  - Can Detect Sudden Damage Due to Impact
  - May Detect Gradual Weakening Due to Aging
- **Limitations**
  - May Require Special "Input" Transducer on Boss
  - Work Needed on Sizing Damage

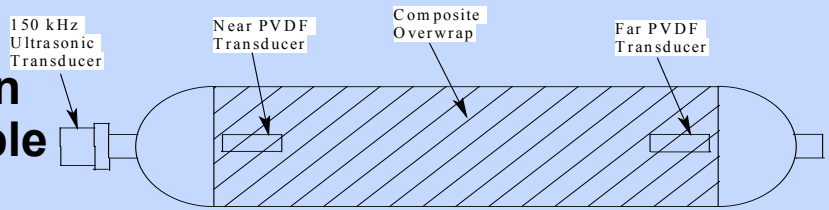
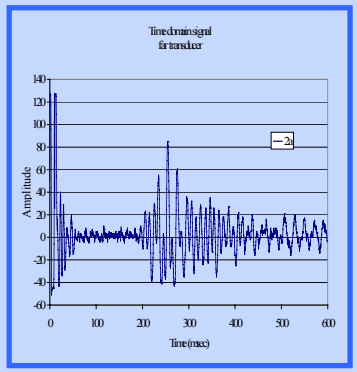
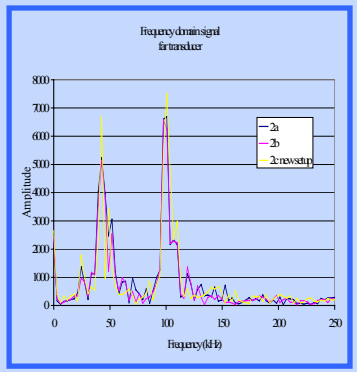


Figure 8. Test setup for PVDF sensor built into NGV cylinder.





Reference Guide for Integration of Natural Gas Vehicle Fuel Systems

- Resource and Reference Guide for Those Involved in Developing, Building and Maintaining Medium and Heavy-duty Natural Gas Vehicles
- Intended to Provide Resources to Help Achieve Greater Reliability in NGV Fuel Systems and NGV Service
- This Reference Guide Includes:
  - System and Component Requirements for Reliability and Durability
  - Design and Integration Considerations
  - Potential Failure Modes and Mitigation Measures
  - Relevant Codes and Standards
  - An Extensive List of References